JC19 Rec'd PCT/PTO 24 MAY 2001

FORM PTO-1390 (REV. 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **10191/1854**
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/856690

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED:
PCT/DE99/03149	**30 September 1999 (30.09.99)**	**24 November 1998 (24.11.98)**

TITLE OF INVENTION
A METHOD AND DEVICE FOR DETECTING AND REMOVING INTERFERENCE PULSES IN A USEFUL SIGNAL

APPLICANT(S) FOR DO/EO/US
Bjoern JELONNEK and Detlev NYENHUIS

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have. been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unsigned).
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☒ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Search Report (translated), Preliminary Examination Report and PCT/RO/101.

EXPRESS MAIL NO.: EL302704195

U.S. APPLICATION NO. (if known, see 37 C.F.R.1.5) 09/856690	INTERNATIONAL APPLICATION NO PCT/DE99/03149	ATTORNEY'S DOCKET NUMBER 10191/1854

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17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EUROPEAN PATENT OFFICE or JPO $860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $710.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,000.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	18 - 20 =	0	X $18.00	$ 0	
Independent Claims	2 - 3 =	0	X $80.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$ 860	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 860	
				Amount to be: refunded	$
				charged	$

a. ☐ A check in the amount of $__________ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of **$860.00** to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

By: [signature] (Reg. No 41,172)

Richard L. Mayer [signature]

SIGNATURE

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5/24/01

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PATENT TRADEMARK OFFICE

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[10191/1854]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	JELONNEK et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	A METHOD AND DEVICE FOR DETECTING AND REMOVING INTERFERENCE PULSES IN A USEFUL SIGNAL
Art Unit	:	To Be Assigned
Examiner	:	To Be Assigned

Assistant Commissioner
for Patents
Washington, D.C. 20231
Box Patent Application

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PRELIMINARY AMENDMENT AND 37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to:

--What Is Claimed Is:--.

Please cancel original claims 1 to 20, without prejudice, and cancel substitute claims 1 to 19, without prejudice, without prejudice, in the underlying PCT Application No. PCT/DE99/03149.

EL302704195

Please add the following new claims:

20. (New) A method for detecting and removing an interference pulse in a useful signal, comprising the steps of:

digitizing the useful signal in order to produce a digital useful signal;

differentiating the digital useful signal in order to produce a differentiated digital useful signal;

calculating a threshold value from the differentiated digital useful signal;

performing a comparison to determine whether the differentiated digital useful signal exceeds the calculated threshold value; and

blanking the interference pulse, if the differentiated digital useful signal is determined to exceed the calculated threshold value.

21. (New) The method according to claim 20, further comprising the step of:

before digitizing the useful signal, band-limiting the useful-signal.

22. (New) The method according to claim 20, wherein:

the step of differentiating includes a high pass filtering.

23. (New) The method according to claim 20, wherein the step of differentiating includes the step of:

separately differentiating an in-phase component of the useful signal from a quadrature component of the useful signal.

24. (New) The method according to claim 20, wherein:

the useful signal is an IF signal of a radio receiver.

25. (New) The method according to claim 24, wherein during the step of blanking, the method further comprises the step of:

retaining, instead of an actual IF signal value, a last undisturbed IF signal value as a condition of relaying the useful signal, a further writing-in of sampling values into a delay line being prevented.

26. (New) The method according to claim 20, wherein:

the useful signal is an AM-modulated signal.

27. (New) The method according to claim 20, wherein the step of calculating includes the steps of:

performing a first adding by adding together an absolute-value of an in-phase component of the useful signal, a quadrature component of the useful signal, and an inverted threshold value that is delayed by one clock-pulse period, the first adding producing a first result,

determining a sign from the first result,

multiplying the sign by the inverted threshold value that is delayed by one clock-pulse period to produce a second result, and

performing a second adding by adding the second result to the inverted threshold value that is delayed by one clock-pulse period to produce a new current threshold value.

28. (New) The method according to claim 27, wherein, before the step of multiplying, the method comprises the step of:

multiplying the inverted threshold value that is delayed by one clock-pulse period by a predetermined parameter α.

29. (New) The method according to claim 27, wherein:

the second adding includes an adding of a predetermined parameter β.

30. (New) The method according to claim 20, wherein the blanking step includes the step of:

blanking a predetermined number of sampling values following the interference pulse.

31. (New) The method according to claim 20, further comprising the step of:

after the blanking step, performing an FIR (finite impulse response) filtering.

32. (New) A device for detecting and removing an interference pulse in a useful signal, comprising:

an A/D converter for converting the useful signal into a digital useful signal;

a device for blanking the digital useful signal in response to a blanking signal; and

a device for detecting the interference pulse and for generating the blanking signal when the interference pulse is recognized, the device for detecting the interference pulse including:

a device for calculating a threshold value,

a device for deciding a presence of the interference pulse, and

a differentiator for generating a differentiated digital useful signal from the digital useful signal, wherein:

the differentiated digital useful signal is fed to the device for calculating the threshold value and to the device for deciding the presence of the interference pulse, and

the device for detecting the interference pulse recognizes the interference pulse in the useful signal when, based on a comparison between the differentiated digital useful signal and the threshold value, the device for deciding the presence of the interference pulse ascertains that the differentiated digital useful signal exceeds the threshold value.

33. (New) The device according to claim 32, wherein the device for calculating the threshold value includes:

at least one absolute-value generating device that generates an absolute-value of at least one component of the digital useful signal,

a first adder that adds all absolute values derived from the digital useful signal and an inverted threshold value that is delayed by one clock-pulse period to produce a first intermediate signal,

a sign calculating device that determines a sign of the first intermediate signal,

a first multiplier that multiplies the sign by the inverted threshold value that is delayed by one clock-pulse period to produce a second intermediate signal,

a second adder that adds the second intermediate signal to the inverted threshold

value that is delayed by one clock-pulse period to produce a new active threshold value, and

a time-delay element that picks off the new active threshold value, the new active threshold value, after being delayed by one clock-pulse period and inverted to the first adder, being supplied by the time-delay element to the second adder and to the first multiplier.

34. (New) The device according to claim 33, further comprising:

a second multiplier arranged between the time-delay element and the first multiplier and for multiplying the inverted threshold value that is delayed by one clock-pulse period by a predetermined parameter α.

35. (New) The device according to claim 33, wherein:

the second adder includes an additional input for achieving an additional adding of a predetermined parameter β.

36. (New) The device according to claim 32, wherein:

the device for blanking includes at least one FIR (finite impulse response) filter having a predefined number N of state memories for reducing sampling rates.

37. (New) The device according to claim 36, wherein:

the device for blanking includes a counter, the counter including an output that drives the state memories of the at least one FIR filter such that, when the interference pulse is detected, for blanking the interference pulse for a predetermined number δ of sampling values, the state memories one of retain their last values before an appearance of the interference pulse and are set at zero.

Remarks

This Preliminary Amendment cancels original claims 1 to 20, without prejudice, and cancels substitute claims 1 to 19, without prejudice, in the underlying PCT Application No. PCT/DE99/03149. The Preliminary Amendment also adds new claims 20-37. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE99/03149 includes an International Search Report, dated March 1, 2000, and an International Preliminary Examination Report, dated March 1, 2001, copies of which are submitted herewith. Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

By: [signature] (Reg. No. 41,172)

Dated: 5/24/01

By: Richard L. Mayer
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[10191/1854]

A METHOD AND DEVICE FOR DETECTING AND REMOVING INTERFERENCE PULSES IN A USEFUL SIGNAL

Field Of The Invention

The present invention relates to a method and a device for detecting and removing interference pulses in a useful signal. The present invention also relates to a radio receiver having an IF stage and an AF stage.

Background Information

By way of example, in the mobile reception of radio signals in a motor vehicle, pulse-like disturbances often arise which are generated by specific assemblies in the motor vehicle, such as the ignition system, windshield wipers, etc. In order to detect interference pulses of this type, conventional AM radio receivers use a broadband IF signal that exists in analog form. If the IF signal exceeds a fixedly predetermined threshold, then the IF signal is recognized as faulty and the receiver interrupts the transmission either of the IF signal, of an AF signal, or of both signals. In this context, however, there is the disadvantage that in response to powerful fluctuations in the signal intensity of the radio, or useful signal, the latter can itself reach an intensity which exceeds the preestablished threshold, so that despite the undisturbed useful signal, a blanking takes place. Conversely, it is possible that interference pulses are not blanked because they lie beneath the fixedly predetermined threshold.

Summary Of The Invention

It is an object of the present invention to achieve an improvement such that interference pulses contained in the useful signal are reliably and automatically detected and are suppressed so as to be substantially inaudible, regardless of the intensity of the useful signal and regardless of the intensity of the interference pulses.

For this purpose, a method of the above-mentioned is characterized according to the present invention by the following steps:

(a) digitizing the useful signal, yielding a digital useful signal,

(b) differentiating the digital useful signal, yielding a differentiated digital useful signal,

(c) calculating a threshold value from the differentiated digital useful signal,

(d) performing a comparison to determine whether the differentiated digital useful signal exceeds the calculated threshold value, and

(e) blanking the interference pulse, if in step (d) it has been determined that the differentiated digital useful signal exceeds the calculated threshold value.

This has the advantage that, on the basis of digital signal processing after an analog/digital conversion of a useful signal, interference pulses contained in the useful signal are reliably detected, filtered out, and suppressed so as to be substantially inaudible.

Aliasing in the analog/digital conversion is avoided as a result of the fact that the useful signal is band-limited before step (a).

In order that the results of the calculation of the threshold value not be invalidated by the power spikes of the interference pulse, the differentiation in step (b) is a high pass filtering, as a result of which interference spikes can be detected more effectively.

In step (b), in the differentiation, an in-phase component as well as a quadrature component of the useful signal are differentiated separately from each other.

In one preferred embodiment, in step (e), during the blanking, instead of an actual IF signal value, a final undisturbed IF signal value is retained or no signal is transmitted, a further writing-in of sampling values into a delay line being prevented.

For illustrative purposes, the useful signal is an IF signal of a radio receiver, and the useful signal is an AM-modulated signal.

It is possible to achieve a threshold value calculation that is independent of the intensity of

any interference signal as a result of the fact that in step (c) an absolute value of an in-phase component as well as of a quadrature component of the useful signal are added together with a threshold value that is inverted and delayed by one clock-pulse period, the sign is determined by the result, it is multiplied by the threshold value that is delayed by one clock-pulse period, and the result is added to the threshold value that is delayed by one clock-pulse period, the final result representing a new current threshold value.

To determine an adaptation speed in calculating the threshold value, before the multiplication using the predetermined sign, the threshold value that is delayed by one clock-pulse period is multiplied by a predetermined parameter α.

To establish a minimal threshold value, in the final addition for calculating the threshold value, a predetermined parameter β is also added.

For the effective elimination of all interference pulse components also of temporally broad interference pulses, in step (e), a predetermined number of sampling values following the detected interference pulse are blanked.

To reduce a sampling rate, after step (e), an FIR filtering (Finite-Impulse-Response filtering) is carried out.

A device of the above-mentioned type is characterized according to the present invention by an A/D converter, which receives the useful signal and relays a digital useful signal to a downstream device for sampling rate reduction and blanking, the device blanking the current digital useful signal at a predetermined signal, a device for detecting an interference pulse picking off the digital useful signal between the A/D converter and the device for sampling rate reduction and blanking, and, when an interference pulse is detected, the predetermined signal is relayed to the device for sampling rate reduction and blanking.

This has the advantage that, on the basis of digital signal processing after the analog/digital conversion of a useful signal, interference pulses contained in the useful signal are reliably detected, filtered out, and suppressed so as to be substantially inaudible.

An elimination of the interference signal that is independent of the intensity of any signal can be achieved as a result of the fact that the device for detecting an interference pulse has a device for calculating the threshold value, which in the signal processing direction includes the following: at least one absolute-value generating device, which generates an absolute-value of at least one component of the digital useful signal; a first adder, which adds all of the absolute values derived from the constituted useful signal as well as an inverted threshold value that is delayed by one clock-pulse period, yielding a first intermediate signal; a sign calculating device, which determines the sign of the first intermediate signal; a first multiplier, which multiplies the sign by the threshold value that is delayed by one clock-pulse period, yielding a second intermediate signal; and a second adder, which adds the second intermediate signal to the threshold value that is delayed by one clock-pulse period resulting in a new current threshold value, a time-delay element picking off the new current threshold value and, delayed by one clock-pulse period and inverted to the first adder, supplying it to the second adder and to the first multiplier.

For performing a comparison to determine an adaptation speed in calculating the threshold value, a second multiplier is provided between the time-delay element and the first multiplier, the second multiplier multiplying the threshold value that is delayed by one clock-pulse period by a predetermined parameter α.

For establishing a minimum threshold value, the second adder has a supplemental input for the additional adding of a predetermined parameter β.

In one preferred embodiment, the device for the sampling rate reduction and blanking has an FIR filter (Finite-Impulse-Response filter) having a predetermined number of state memories.

In addition, the device for the sampling rate reduction and blanking preferably includes a counter, whose output drives the state memories of the FIR filter such that, when an interference pulse is detected, for the purpose of blanking the pulse for a predetermined number δ of sampling values, the state memories retain their last values before the appearance of the interference pulse, or they are set at zero.

A radio receiver of the above-mentioned type, in accordance with the present invention, has a device of the aforementioned type upstream of the IF stage.

Brief Description Of The Drawings

Figure 1 depicts a schematic block diagram of a preferred embodiment of a device according to the present invention.

Figure 2 depicts a schematic block diagram for detecting an interference pulse in the embodiment according to Figure 1.

Figure 3 depicts a schematic circuit diagram of a preferred exemplary embodiment for a digital high pass filter.

Figure 4 depicts a schematic circuit diagram of a preferred embodiment for a digital threshold value calculation in accordance with the present invention.

Figure 5 depicts a schematic circuit diagram of a preferred exemplary embodiment for a digital interference pulse detection circuit.

Figure 6 depicts a schematic circuit diagram of a preferred exemplary embodiment for a digital circuit for reducing the sampling rate and for blanking an interference pulse.

Figure 7 depicts a schematic circuit diagram of a preferred exemplary embodiment for a digital counter.

Figure 8 depicts a schematic circuit diagram of a preferred exemplary embodiment for a digital decimation filter.

Detailed Description

Below, the present invention is discussed on the basis of a preferred embodiment in the

example of a radio receiver for AM-modulated signals, it nevertheless being clear that the present invention is not limited to this specific application.

Figure 1 depicts a schematic block diagram of device 100 according to the present invention, which, downstream of appropriate input circuits of the radio receiver of an undepicted IF stage, receives an analog IF signal 10 and, in an analog/digital converter 12, converts it into a digital IF signal 13. In function block 14, a sampling rate reduction takes place, for example using an FIR filter (Finite-Impulse-Response filter) discussed in greater detail below with reference to Figure 8, as well as, if an interference pulse should arise, a blanking. In a downstream function block 16, an IF filtering takes place and, subsequently, an AM-demodulation and the transmission of an AF signal 18 to a downstream, undepicted AF stage of the radio receiver. The digital IF signal of useful signal 13 is then conveyed to a function block 20, in which interference pulses are detected. If an interference pulse is detected, function block 20 emits an appropriate signal 22 to function block 14, so that the blanking is activated in the latter.

Figure 2 depicts in greater detail function block 20 for detecting an interference pulse. In this context, digital IF signal 13 is conveyed to a function block 24, which generates a differentiated digital useful signal 26, which is supplied both to a function block 28 for calculating a threshold value as well as to a function block 30 for performing a comparison to determine whether an interference pulse is present.

The exemplary embodiment depicted in Figure 3 of a function block 24 includes two signal lines 32 and 34 for an in-phase IF signal 36 and a quadrature IF signal 38. Both signals 36 and 38 are conveyed to an adder 40 and a time-delay element 42, which delays the signal, or the sampling value, by one clock-pulse period. The signal, delayed by one clock-pulse period, from time-delay element 42 is conveyed in inverted form to adder 40, so that on both lines 46 and 48, a differentiator 24, 40, 42 is realized. This arrangement acts on signals 36 and 38 the way a high pass filter acts on an analog signal, so that function block 24 can also be termed a high pass filter. Differentiated digital useful signal 26 is therefore essentially a digital useful signal that has been high-pass filtered. Therefore, at the output of function block 24, a high-pass-filtered in-phase signal 46 and a high-pass-filtered quadrature signal 48 are present.

In function block 20 (Figure 2), high-pass-filtered digital useful signal 26 is compared with a threshold value 44 emerging from function block 28. If high-pass-filtered digital useful signal 26 exceeds threshold value 44, then an interference pulse is detected by function block 30 and an appropriate blanking signal 22 is emitted to function block 14 (Figure 1).

In the preferred embodiment of function block 30, depicted in Figure 5, to decide whether an interference pulse is present or not, differentiated digital useful signal 26, or its quadrature component 48 and in-phase component 46, are subjected in 50 to an absolute-value generation, and, in a first adder 52, the generated absolute-values are added to each other. In a downstream multiplier 54, the signal that is obtained in this manner is multiplied by a predetermined parameter χ, χ constituting a scaling factor, and the signal is transmitted over line 96. In a further adder 56, the scaled signal and inverted threshold value 44 are added together, yielding blanking signal 22 as the detector output signal.

As can be seen from the depiction of an exemplary embodiment of function block 14 in Figure 6, detector output signal 22 is conveyed to a register 58. A counter output 60 acts upon each decimation filter 62 for in-phase IF signal 36 and quadrature IF signal 38 of digital IF signal 13 such that the state memories contained in the decimation filters retain their currently stored value if detector output signal 22 signals an interference pulse. In other words, despite the continuing system clock-pulse, no new sampling values are registered in the state memories of decimation filters 62, so that the state of the decimation filters existing just prior to the interference pulse is retained. I.e., for blanking the interference pulse, the signal, or the sampling values, that was/were present in still undisturbed form immediately before the appearance of the interference pulse, is/are retained and relayed.

It is advantageous to discard not only the sampling value corresponding temporally to the interference pulse and to maintain the prior undisturbed sampling value, but also to discard and not to register in the state memories of decimation filters 62 a predetermined number of sampling values following the interference pulse. This is achieved by register 58, which is depicted in an exemplary embodiment in Figure 7. After the appearance of an interference pulse, which is indicated by detector output signal 22, register 58 counts backwards to zero from a predetermined value δ, which is supplied via line 98, so that altogether $\delta + 1$ sampling

It is advantageous to discard not only the sampling value corresponding temporally to the interference pulse and to maintain the prior undisturbed sampling value, but also to discard and not to register in the state memories of decimation filters 62 a predetermined number of sampling values following the interference pulse. This is achieved by register 58, which is depicted in an exemplary embodiment in Figure 7. After the appearance of an interference pulse, which is indicated by detector output signal 22, register 58 counts backwards to zero from a predetermined value δ, which is supplied via line 98, so that altogether δ + 1 sampling values are blanked or discarded. For this purpose, in response to a negative detector output signal 22 indicating an interference pulse, value δ is stored in a time-delay element 64. At the same time, counter output 60 is equal to δ, i.e., is greater than zero, as a result of which the counter-output-driven state memories of decimation filters 62 (Figure 6) retain their earlier value and new sampling values are discarded. As long as register 58 is counting from δ to zero, this state remains unchanged, so that corresponding in-phase component 66 and quadrature component 68 of IF signal 70 emerging from function block 14 are corrected accordingly, i.e., the interference pulses are blanked.

The process of counting down in register 58, as is illustrated in Figure 7, is accomplished by adding "-1" to the content of time-delay element 64 in an adder 71 and by writing the new value into time-delay element 64. After the counting down, i.e., as soon as the value "-1" is written into time-delay element 64, counter output 60 is once again negative and the state memories of the decimation filters again operate normally, i.e., in response to each system pulse, a new sampling value is written into the state memories.

Figure 8 depicts a preferred exemplary embodiment for decimation filters 62 in accordance with Figure 6, in the form of an FIR filter (Finite-Impulse-Response filter), decimation filter 62 for in-phase signal 36 being depicted by way of example in Figure 8. In addition, a further corresponding decimation filter for quadrature signal 38 of IF signal 13 is provided. Since both decimation filters 62 in Figure 6 have the same design and the same mode of functioning, the following explanations apply both for decimation filter 62 for in-phase signal 36 as well as for the identical, but undepicted decimation filter 62 for quadrature signal 38, it being necessary, for the input signal, merely to replace in-phase signal 36 by quadrature signal 38 and, for the output signal, to replace in-phase signal 66 by quadrature signal 68. In each system pulse, one sampling value of digital useful signal 36 is written into state

memories 72, or is conveyed further from one state memory 72 to the next one. In accordance with the sampling rate reduction desired, N state memories 72 are provided. Furthermore, in each system pulse, the content of state memories 72 is multiplied in multiplier 74 by a specific coefficient a_n, where n is equal to 1,2,... N, so that ultimately in-phase signal 66 of IF signal 70 results. Counter output 60 acts upon each state memory 72 in the manner described above. State memories 72 are also termed a "delay line."

Optimal parameter δ is preferably determined and set empirically. For example, at a system pulse frequency of 200 kHz and a corresponding period of a system clock-pulse of 5 µs, when $\delta = 8$ and an interference pulse is detected, then an overall blanking time of 40 µs results, corresponding to nine system clock-pulses, because the sampling value carrying the interference pulse itself as well as the succeeding eight sampling values are discarded, until counter output 60 is once again negative (counting backwards from eight to zero).

One preferred exemplary embodiment for a device 28 according to the present invention for calculating the threshold value is depicted in Figure 4. It includes: a device for generating an absolute-value 76, which generates an absolute-value of in-phase component 46 and quadrature component 48 of differentiated digital useful signal 26; a first adder 78, which adds all of the absolute-values, generated from useful signal 13, and an inverted threshold value, delayed by one clock-pulse period, yielding a first intermediate signal 80; a sign calculating device 82, which determines the sign of first intermediate signal 80; a first multiplier 84, which multiplies the sign by the threshold value that is delayed by one clock-pulse period, yielding a second intermediate signal 86; and a second adder 88, which adds second intermediate signal 86 to the threshold value that is delayed by one clock-pulse period, yielding a new current threshold value 44, a time-delay element 90 picking off new current threshold value 44 and, delayed by one clock-pulse period and inverted to first adder 78, conveying it to second adder 88 and to first multiplier 84.

In addition, between time-delay element 90 and first multiplier 84 a second multiplier 92 is provided, which multiplies the threshold value that is delayed by one clock-pulse period by a predetermined parameter α. Second adder 88 has an additional input 94 in order also to add a predetermined parameter β. Performing a comparison to determine the sign in block 82 essentially corresponds to a reduction in the sampling value by a 1-bit information unit,

which in downstream integrator 90 is integrated over time. On account of sign determination 82, interference pulses have only a slight influence on the threshold value calculation.

Parameter α determines an adaptation speed of the integrator generated by time-delay element 90. Parameter β optionally establishes a minimum threshold value. As a result of the sign determination in block 82, in calculating the threshold value, a power output of interference spikes is eliminated, so that the result of the threshold value calculation is not influenced by the interference spikes themselves. Instead, after a predetermined time, a threshold value 44 always arises that is exclusively a function of the actual useful signal. This threshold value 44, in this context, is not necessarily a whole-number multiple of the average value of the useful signal. In other words, the power output of the interference spikes is limited, so that it does not falsify the result of the threshold value calculation. On the other hand, according to the invention, the threshold for detecting interference pulses is not fixedly prescribed but rather is calculated using circuit 28 in an adaptive manner, in accordance with the conditions of reception. This results in particularly effective interference pulse suppression even when reception conditions fluctuate, because threshold value 44 adjusts to a new situation accordingly.

New Claims

What is claimed is:

1. A method for detecting and removing interference pulses in a useful signal,

(a) the useful signal being digitized to a digital useful signal,

characterized by the following steps:

(b) differentiating the digital useful signal, yielding a differentiated digital useful signal;

(c) calculating a threshold value from the differentiated digital useful signal;

(d) performing a comparison to determine whether the differentiated digital useful signal exceeds the calculated threshold value; and

(e) blanking the interference pulse, if it is determined in step (d) that the differentiated digital useful signal exceeds the calculated threshold value.

2. The method as recited in Claim 1,
wherein the useful signal is band-limited before step (a).

3. The method as recited in Claim 1 or 2,
wherein the differentiation in step (b) is a high pass filtering.

4. The method as recited in one of the preceding claims,
wherein in step (b), in the differentiation, an in-phase component, as well as a quadrature component of the useful signal are differentiated separately from each other.

5. The method as recited in one of the preceding claims,
wherein the useful signal is an IF signal of a radio receiver.

6. The method as recited in Claim 5,
wherein in step (e), during the blanking, instead of an actual IF signal value, a last undisturbed IF signal value is retained or no signal is relayed, a further writing-in of sampling values into a delay line being prevented.

7. The method as recited in one of the preceding claims,
wherein the useful signal is an AM-modulated signal.

8. The method as recited in one of the preceding claims,
wherein in step (c), an absolute-value of an in-phase component as well as of a quadrature component of the useful signal are added together, along with an inverted threshold value that is delayed by one clock-pulse period, the sign is determined from the result, it is multiplied by the threshold value that is delayed by one clock-pulse period, and the result is added to the threshold value that is delayed by one clock-pulse period, the final result representing a new current threshold value.

9. The method as recited in Claim 8,
wherein, before the multiplication by the predetermined sign, the threshold value that is delayed by one clock-pulse period is multiplied by a predetermined parameter α.

10. The method as recited in Claim 8 or 9,
wherein, in the final addition for calculating the threshold value, a predetermined parameter β is also added.

11. The method as recited in one of the preceding claims,
wherein in step (e), a predetermined number of sampling values following the detected interference pulse is blanked.

12. The method as recited in one of the preceding claims,
wherein after step (e), an FIR filtering (finite impulse response filtering) is carried out.

13. A device for detecting and removing interference pulses in a useful signal,
having an A/D converter (12) for converting the useful signal (10) into a digital useful signal (13), having a device (14) for blanking the digital useful signal (13) in response to a blanking signal (22), and having a device (20) for detecting an interference pulse and for generating the blanking signal (22) when an interference pulse is recognized which includes a device (28) for calculating a threshold value (44) and a device (30) for deciding the presence of an interference pulse,

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wherein the detecting device (20) has a differentiator (24) for generating a differentiated, digital useful signal (26) from the digital useful signal (13);
the differentiated, digital useful signal (26) is fed to the device (28) for calculating threshold values and to the deciding device (30);
the detecting device (20) recognizes an interference pulse in the useful signal when, based on a comparison between the differentiated digital useful signal (26) and the threshold value (44), the deciding means (30) ascertains that the differentiated useful signal (26) exceeds the threshold value (44).

14. The device (100) as recited in Claim 13,
wherein the device (28) for calculating the threshold value in the direction of signal processing includes:

- at least one absolute-value generating device (76), which generates an absolute-value of at least one component (46, 48) of the digital useful signal (26);
- a first adder (78), which adds all of the absolute values derived from the generated useful signal (26) and an inverted threshold value that is delayed by one clock-pulse period, yielding a first intermediate signal (80);
- a sign calculating device (82), which determines the sign of the first intermediate signal (80);
- a first multiplier (84), which multiplies the sign by the threshold value that is delayed by one clock-pulse period, yielding a second intermediate signal (86);
- and a second adder (88), which adds the second intermediate signal (86) to the threshold value that is delayed by one clock-pulse period, yielding a new active threshold value (44), a time-delay element (90) picking off the new active threshold value (44) and, delayed by one clock-pulse period and inverted to the first adder (78), supplying it to the second adder (88) and to the first multiplier (84).

15. The device (100) as recited in Claim 14,
wherein between the time-delay element (90) and the first multiplier (84), a second multiplier (92) is provided, which multiplies the threshold value that is delayed by one clock-pulse period by a predetermined parameter α.

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16. The device (100) as recited in Claim 14 or 15,
wherein the second adder (88) has an additional input (94) for the additional adding of a predetermined parameter β.

17. The device (100) as recited in one of Claims 13 through 16,
wherein the device (14) for blanking has at least one FIR filter (finite impulse response filter) (62) having a predefined number N of state memories (72) for reducing sampling rates.

18. The device (100) as recited in Claim 17,
wherein the device (14) for sampling rate reduction and blanking has a counter (58), whose output (60) drives the state memories (72) of the FIR filter (62) such that, when an interference pulse is detected, for blanking said pulse for a predetermined number δ of sampling values, the state memories (72) retain their last values before the appearance of the interference pulse, or they are set at zero.

19. Use of the device (100) as recited in one of Claims 13 through 18 in a radio receiver, wherein the device is arranged upstream of an IF stage.

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Abstract

The present invention relates to a device (100) and a method for detecting and removing interference pulses in a useful signal. The device according to the present invention includes an A/D converter (12), which receives the useful signal (10) and relays a digital useful signal (13) to a downstream device (14) for sampling rate reduction and blanking, which, in response to a predetermined sign (22), blanks the current digital useful signal (13), a device (20) for detecting an interference pulse picking off the digital useful signal (13) between the A/D converter (12) and the device (14) for sampling rate reduction and blanking and, when an interference pulse is detected, relaying the predetermined signal (22) to the device (14) for sampling rate reduction and blanking. (Figure 1).

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Fig.1

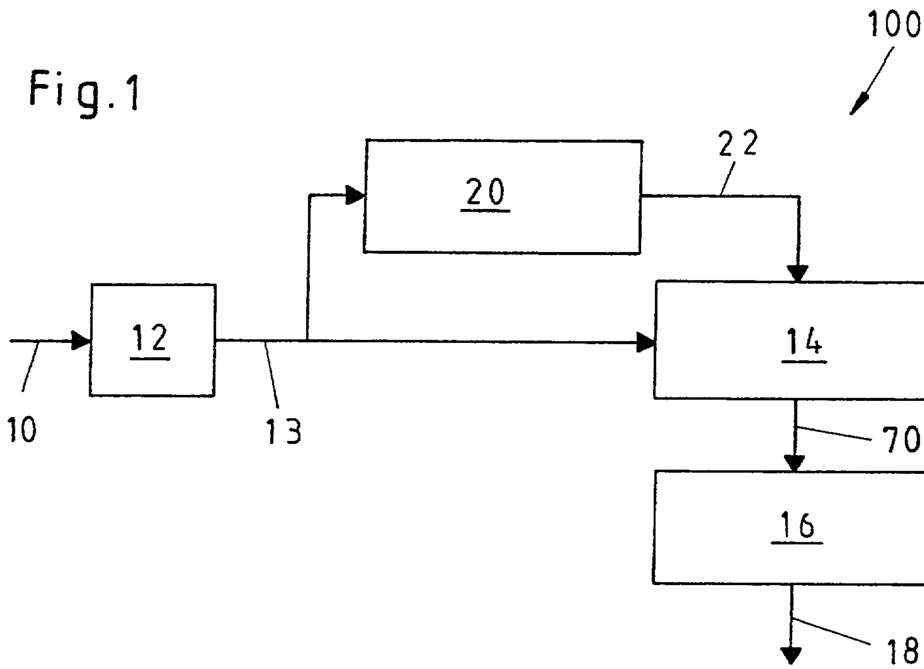

Fig. 2

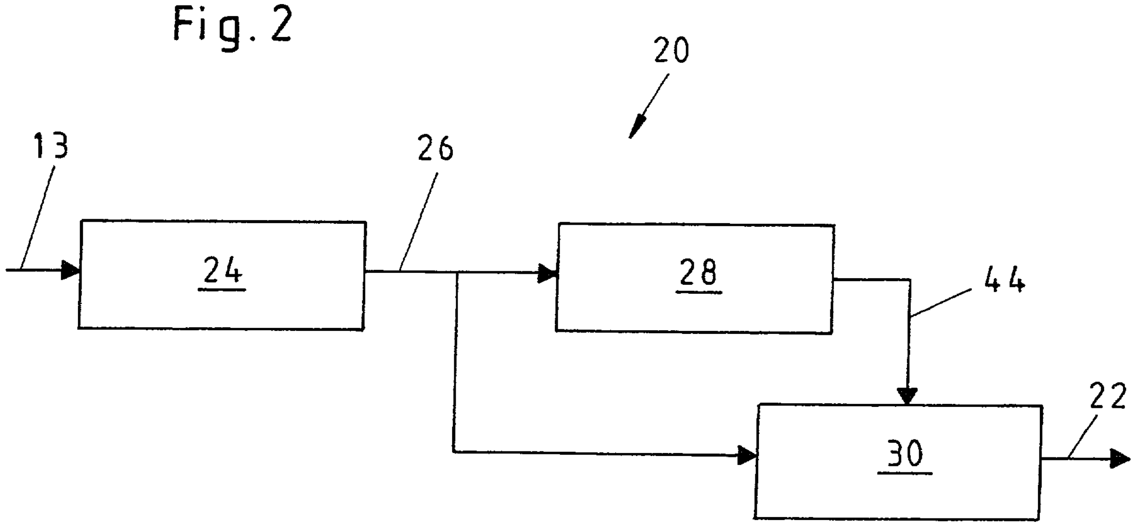

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Fig. 3

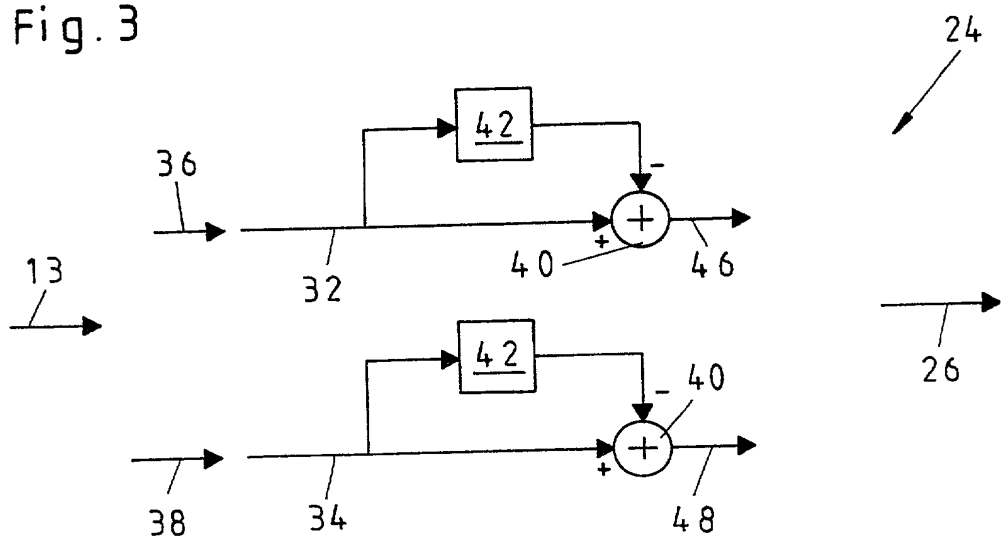

Fig. 4

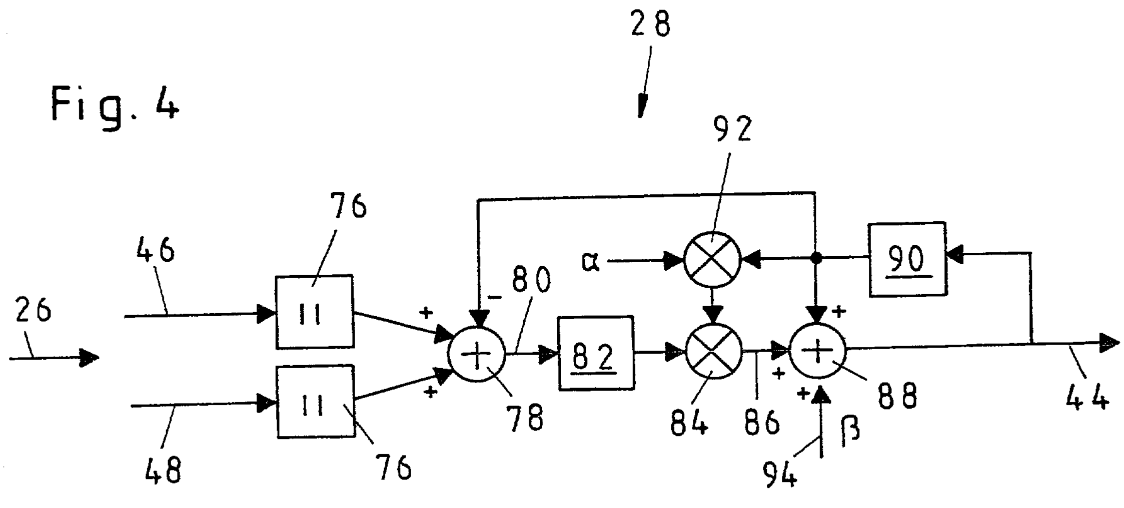

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Fig.5

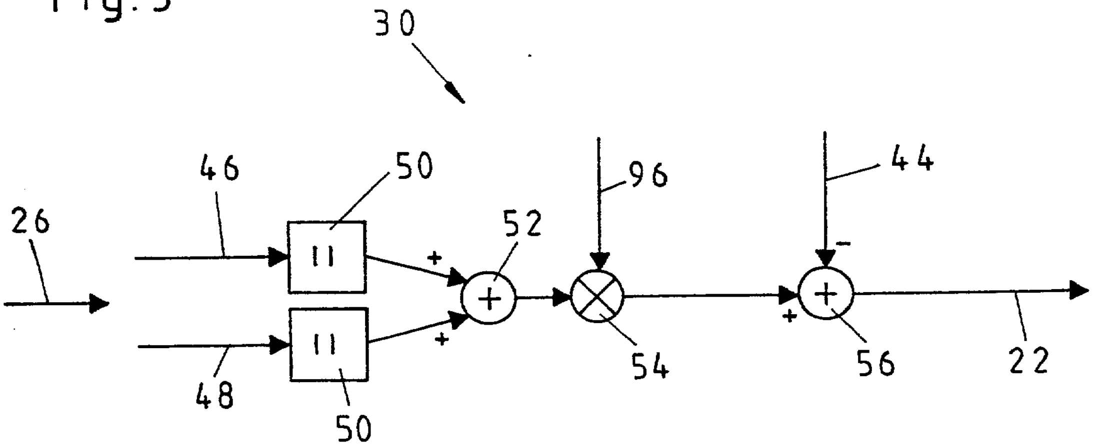

Fig.6

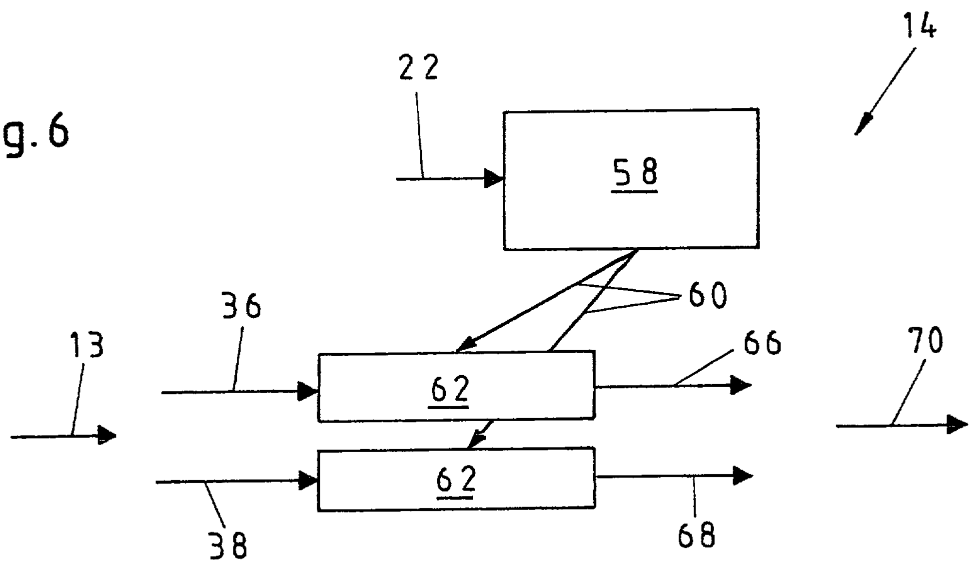

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Fig.7

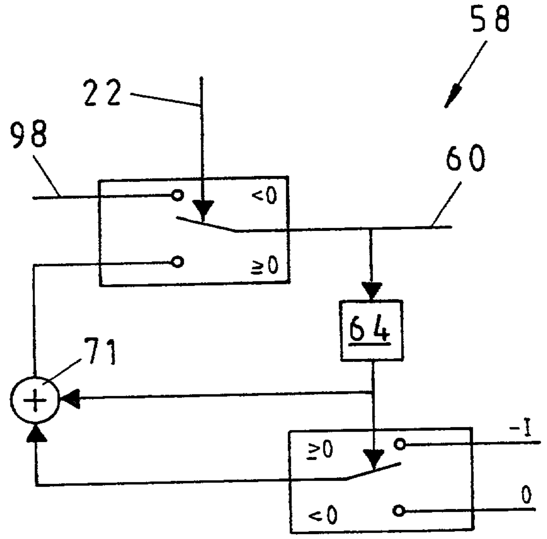
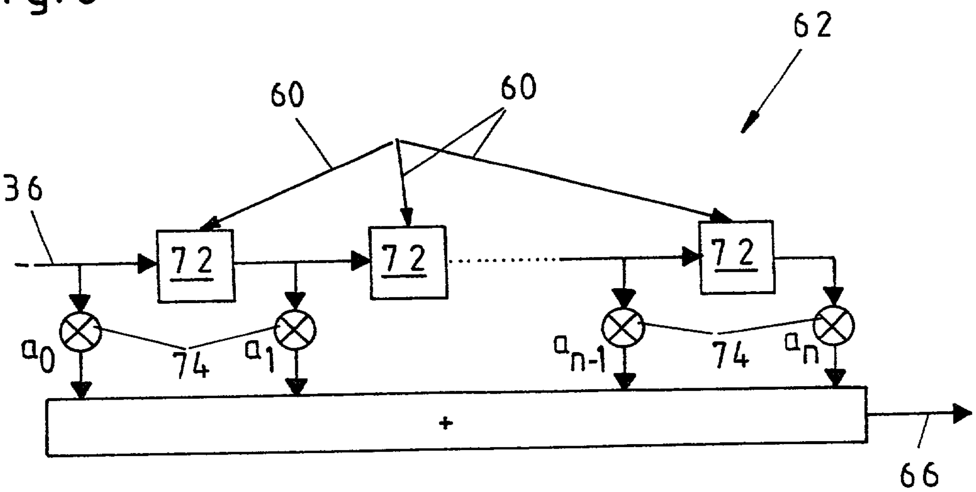


Fig.8



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[10191/1854]

COMBINED DECLARATION AND
POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **A METHOD AND DEVICE FOR DETECTING AND REMOVING INTERFERENCE PULSES IN A USEFUL SIGNAL**, and the specification of which:

[ ] is attached hereto;

[ ] was filed as United States Application Serial No. and,

[x] was filed as PCT International Application Number PCT/DE99/03149, on the 30th day of September, 1999

[ ] an English translation was previously submitted.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

EL244506357US

PRIOR FOREIGN/PCT APPLICATION(S)
<u>AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119</u>

Country : Federal Republic of Germany

Application No. : 198 54 073.6

Date of Filing: 24 November 1998

Priority Claimed
Under 35 U.S.C. § 119 : [x] Yes [ ] No

I hereby claim the benefit under Title 35, United States Code § 120 of any United States Application or PCT International Application designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR
PCT INTERNATIONAL APPLICATIONS
DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120

<u>U.S. APPLICATIONS</u>

Number :

Filing Date :

PCT APPLICATIONS
<u>DESIGNATING THE U.S.</u>

PCT Number :

PCT Filing Date :

I hereby appoint the following attorney(s) and/or agents to prosecute the above-identified application and transact all business in the Patent and Trademark Office connected therewith.

(List name(s) and registration number(s)):

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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